

Patients' Acceptance of Internet-based Home Asthma Telemonitoring

Joseph Finkelstein¹, M.D., Ph.D., George Hripcsak¹, M.D., Manuel R. Cabrera², M.D.
¹Department of Medical Informatics and ²Department of Medicine
Columbia University, New York

ABSTRACT

We studied asthma patients from a low-income inner-city community without previous computer experience. The patients were given portable spirometers to perform spirometry tests and palmtop computers to enter symptoms in a diary, to exchange messages with physician and to review test results. The self-testing was performed at home on a daily basis. The results were transmitted to the hospital information system immediately after completion of each test. Physician could review results using an Internet Web browser from any location. A constantly active decision support server monitored all data traffic and dispatched alerts when certain clinical conditions were met.

Seventeen patients, out of 19 invited, agreed to participate in the study and have been monitored for three weeks. They have been surveyed then using standardized questionnaire. Most of the patients (82.4%) characterized self-testing procedures as "not complicated at all." In 70.6% of cases self-testing did not interfere with usual activities, and 82.4% of patients felt the self-testing required a "very little" amount of their time. All patients stated that it is important for them to know that the results can be reviewed by professional staff in a timely manner. However, only 29.5% of patients reviewed their results at least once a week at home independently. The majority of the patients (94.1%) were strongly interested in using home asthma telemonitoring in the future. We concluded that Internet-based home asthma telemonitoring can be successfully implemented in the group of patients without previous computer background.

INTRODUCTION

Recent studies have shown that long-term monitoring of asthma severity can help to prevent asthma exacerbation, optimize drug therapy and decrease the cost of asthma management [1]. Asthma patients frequently underestimate the severity of their symptoms which can lead to hospitalization or even death from asthma attack [2]. Pulmonary function monitoring can indicate upcoming exacerbation several days before patient starts feeling deteriorating symptoms. Existing systems for home asthma monitoring, which are predominantly based on peak flow measurement, do not provide precise tools for evaluation of asthma severity, do not support analysis

of the results in a timely manner and lack decision support tools [3,4]. We developed a Web-based system which provides constant reciprocal information exchange between asthma patients and the health care provider, and implements real-time clinical decision support tools.

The design and structure of our Internet-based home asthma telemonitoring system has been previously described [5,6]. Briefly, asthma patients use a portable spirometer and a palmtop computer for self-testing at home. Spirometer is connected to the palmtop via serial port and is used by patients to perform Forced Vital Capacity (FVC) test. Patients use palmtop to enter symptom diary, to exchange messages with health care provider, and to review test results. Immediately after completion of the self-testing the palmtop transmits the results from patients' homes to a hospital information system via phone or wireless network. Minutes later the results can be reviewed and analyzed by physicians using an Internet Web browser from any location. The system provides daily monitoring of 29 spirometry indices, the flow-volume loop and symptom scores. A constantly active decision support server monitors all data traffic between patient and physician. It generates alerts based on changes in data trends and development of certain clinical conditions. The thresholds for alerts can be dynamically set by the physician at the designated Web site.

The user interface for home data entry was modeled after an Automated Teller Machine (ATM). This approach was designed to simplify and speed up data entry without any special assumptions about the user skills. According to this approach, our palmtop software leads the patient through the self-testing procedure by proposing the patients small sets of choices following one after another. A minimal number of buttons are used for data entry.

Despite our efforts to simplify the use of our system at patients' homes, we thought it still might present a challenge for patients with limited exposure to new technologies. This study assessed the ability of inexperienced patients to use our Internet-based home asthma telemonitoring system on regular daily basis.

METHODS

Asthma patients who resided in a low-income inner city area and attended an outpatient pulmonary clinic during study period were asked to participate in the study. Any patient meeting eligibility criteria and available during the study period was selected for participation in the study without any additional considerations such as their computer background or motivation level. The eligibility of patients to participate in the study was based on a previous diagnosis of asthma, absence of psychiatric or contagious diseases and ability to comprehend simple instructions in English. The study was approved by Institutional Review Board and participating patients signed a written consent before beginning home telemonitoring. The patients were instructed about their right to withdraw from the study at any time.

At the beginning of the study each patient received a 30-40 minute instruction session during which he or she was taught how to use the equipment, perform the spirometry test, fill in the diary and review the test results. The patients were instructed to perform self-testing in the morning and evening on a daily basis. The self-testing included filling in a symptom diary and performing a spirometry test. Each spirometry test consisted of three FVC maneuvers as required by American Thoracic Society guidelines for spirometry [7]. Patients were given a phone number to call in the case of any additional questions. They were also able to send messages to their health care provider using the palmtop. The patients' performance was monitored by the decision support server and also the self-testing results were reviewed by professional staff using an Internet browser. In the case of any deviations from the protocol or when certain clinical conditions occurred, the patients were contacted via telephone or by sending a message to patients' palmtop. Decision support server dispatched alerts for patients and physicians according to parameters and compliance thresholds set up by the physician for each particular patient.

Evaluation of patients' acceptance of home asthma telemonitoring was performed according to the guidelines for assessing telecommunications in health care [8]. Patients were asked to answer a standardized questionnaire after three weeks of telemonitoring. The survey was generally obtained at patients' homes by a visiting nurse or other medical professionals during a scheduled visit.

The questionnaire consisted of two parts (Tables 1 and 2). The first part was designed to evaluate patients' background pertinent to the use of new technology. It included demographic data and questions to assess

patients' computer literacy, English proficiency and asthma self-perception using a four-grade scale. The second part of the questionnaire measured patients attitude towards the use of our asthma telemonitoring system. The questions in this part were intended to get insight about several aspects of patients' perception of our system. We wanted to learn how difficult from the patients' perspective was the self-testing in general and its certain parts in particular (spirometry, computer, diary, etc.), how time consuming the daily self-testing routine was perceived, what would be maximal tolerable frequency for self-testing, how often patients reviewed the results of self-testing independently, whether they were able to get all necessary self-testing skills during introductory training session and how interested they were to use such a system in the future. Most of the questions had four possible answers, graded from zero to three. We used alternate sequence of answers to different questions, from most favorable to the least favorable or vice versa, in order to avoid "expectation" bias and "halo effects" [9]. We also tried to express our questions in the simplest possible way and to avoid additional hidden questions inside the original one [10]. All graded choices for patients' answers included short explanations, according to published requirements for questionnaires [9].

RESULTS

From the 19 consecutive asthma sufferers meeting eligibility criteria, 2 patients refused to take part in the research study. The other 17 patients were enrolled in the study and have been monitored for 3 weeks.

The background characteristics of the patients who participated in the study are presented in the Table 1. A majority (76.4%) of the patients characterized themselves as Hispanic, 11.8% of patients described themselves as black or African American, and the other 11.8% described themselves as white. Most of the patients (58.8%) were born outside the continental part of the United States. The mean age was 44.1 ± 3.4 years, ranging from 22 to 68 years old. Demographic data showed that 58.8% of the patients were older than 40 years and 35.3% were older than 55. The average time spent in school by the patients was 9.8 ± 0.4 years and varied from 8 to 14 years. Most of the patients (76.5%) were covered by Medicare or Medicaid. According to patients' self-assessment, different levels of asthma severity were presented in the studied group. Most of these patients had long history of asthma with prior emergency room admissions or hospitalization. The survey showed that 41.2% of patients were employed permanently; 53% of the patients claimed that they had never used an ATM;

Table 1. Background characteristics of the patients.

Question	Answer			
	0	1	2	3
Race/Ethnicity	African American	Asian	Hispanic	White
	11.8%	0%	76.4%	11.8%
Born in the continental part of the U.S.	No	Yes	N/A	N/A
	58.8%	41.2%		
Health insurance	No insurance	Medicare	Medicaid	Private/HMO/Other
	0%	23.5%	53%	23.5%
Asthma severity/Self-reported	None	Mild	Moderate	Severe
	0%	29.4%	41.2%	29.4%
Job	Permanent	Temporary/Part time	Student	None
	41.2%	17.6%	5.9%	35.3%
How often do you use ATM	Once a day	Once a week	Once a month	Never
	5.9%	23.5%	17.6%	53.0%
How often do you use computer at home	Once a day	Once a week	Once a month	Never
	5.9%	0%	0%	94.1%
How often do you use computer at work	Once a day	Once a week	Once a month	Never
	23.5%	0%	0%	76.4%
English proficiency/Self-reported	Excellent	Good	Poor	None
	53%	29.4%	17.6%	0%

76.4% of the patients had never used a computer; 47.1% of the patients had never used a computer or an ATM. The patients scored their proficiency in English as excellent or good in 82.4% of cases. Most of the patients (58.8%) identified Spanish as their native language and English as a second language. The rest of the patients (41.2%) considered English their native language.

Table 2 summarizes patients' answers to the second part of the questionnaire, intended to assess the patients' attitude towards the home asthma telemonitoring program. The table includes 12 questions, which were graded from 0 to 3. Each cell in the table indicates a choice and the corresponding percentage of patients who chose it.

Most of the patients (82.4%) characterized self-testing procedures as "not complicated at all." The majority of the patients also indicated that performing spirometry test (94.1%) or working with palmtop (94.1%) or answering symptom diary questions (88.2%) was "not difficult at all." All three patients who characterized self-testing procedures as "slightly complicated" also indicated that some particular part or parts of self-testing were "slightly difficult." Two of those patients characterized answering symptom diary questions as being "slightly difficult." The same two patients scored their English proficiency as poor. The third patient described performing spirometry test and working with the palmtop as "slightly difficult".

This patient also indicated that she was not provided with complete information about self-testing during the initial training session.

None of the patients felt that self-testing required "considerable" or "very significant" amount of time. Most of the patients claimed that self-testing took a "very little" amount of time. In 70.6% of cases there was no interference between self-testing and usual activities. Those patients who found "very little" or "little" interference between self-testing and usual activities had also a permanent job. Not all patients with a permanent job reported such interference.

Only 29.5% of patients reviewed their results at least once a week. More than half of patients (52.9%) never reviewed the results of self-testing independently. However, all patients stated that it is (extremely – 82.4%, very – 17.6%) important for them to know that the results can be reviewed in the medical center immediately after the test. The survey showed that 88.2% of patients felt safer while being monitored by our system. The majority of the patients (94.1%) were strongly interested in using the home asthma telemonitoring system in the future.

DISCUSSION

The analysis of our patients' background revealed a socio-economic profile and level of computer literacy which appeared to be the least favorable towards successful employment of new computerized

Table 2. Survey results of the patients' perception of the Internet-based home asthma telemonitoring system.

Question	Score			
	0	1	2	3
How complicated were the self-testing procedures	Very complicated	Moderately complicated	Slightly complicated	Not complicated at all
	0%	0%	17.6%	82.4%
How much of your time did the self-testing take	A very significant amount of time	Considerable	Little	Very little
	0%	0%	17.6%	82.4%
Would you like to use this self-testing program in the future	Certainly yes	May be	Unlikely	No
	94.1%	5.9%	0%	0%
Did the self-testing interfere with your usual activities	No	Very little	Little	A great deal
	70.6%	17.6%	11.8%	0%
How difficult was performing spirometry test	Very difficult	Moderately difficult	Slightly difficult	Not difficult at all
	0%	0%	5.9%	94.1%
How difficult was working with palmtop	Very difficult	Moderately difficult	Slightly difficult	Not difficult at all
	0%	0%	5.9%	94.1%
How difficult was answering symptom diary questions	Very difficult	Moderately difficult	Slightly difficult	Not difficult at all
	0%	0%	11.8%	88.2%
Do you feel safer while being monitored by our system	Significantly safer	Moderately safer	Slightly safer	The same as usual
	29.4%	41.2%	17.6%	11.8%
How important for you is to know that the results of your self-testing can be reviewed in the medical center immediately after the test	Extremely important	Very important	Uncertain	Not important at all
	82.4%	17.6%	0%	0%
How often do you review the test results	Once a day	Once a week	Once a month	Never
	11.9%	17.6%	17.6%	52.9%
Did you get all necessary information about self-testing during the first introductory meeting	All information	Almost all	Partial information	Very limited information
	76.5%	23.5%	0%	0%
What is the maximal frequency of self-testing you can tolerate	Once a day	Two times a day	Three times a day	Four times a day
	17.6%	11.8%	53%	17.6%

technologies. The majority of our patients never used a computer before the study. About half of the patients even did not have experience in using ATM service, which can be considered as rudimentary analog of computer-based data entry. More than half of the patients were born outside continental part of the United States and considered English as their second language. Significant part of our patients were older than 40 years and more than third of them were older than 55.

The analysis of the second part of the questionnaire showed a high degree of acceptance of the home asthma telemonitoring system. The majority of the patients found home telemonitoring easy to use and described the spirometry test, working with the computer to enter data and answering symptom diary questions as "not difficult at all." Patients who scored self-testing as "slightly difficult" also indicated that they did not receive all necessary information about self-testing procedures during initial training session. This fact emphasizes the importance of comprehensive training of patients for successful home telemonitoring. Most of the patients considered one training session sufficient for acquiring all necessary skills for self-testing at home.

Almost all patients expressed a strong willingness to use such a system in the future. Most of the patients felt safer while being monitored by the system. Patients who did not feel safer also indicated their interest in using home telemonitoring in the future. Surprisingly, more than half of the patients never reviewed their results of self-testing. However, the same patients indicated that it is extremely important for them to know that their results can be reviewed in medical center immediately after the test. This data may indicate that these patients are ready to perform self-testing but prefer the interpretation of the results to be done by professional staff.

The optimistic results indicating positive attitude of the patients towards our home telemonitoring system did not appear to be due to selection bias. The majority of the patients had a background which can be considered as least favorable for a successful acceptance of new computerized technologies. The level of their motivation or computer literacy had not been taken into consideration at the beginning of the study. These patients were free to withdraw from the study at any time. The patients were not paid any stipend for participation in the study and they also were responsible for the coverage of telephone expenditures attributed to telemonitoring (about \$15/month). The positive attitude of the patients towards the home telemonitoring probably may be

related to the history of their disease, which includes frequent emergency room visits or hospitalization. We think that our system has addressed the intrinsic need of such patients to have a constant information link with their physician, coupled with knowledge that the results of their self-testing can be analyzed by professional staff on regular basis.

CONCLUSIONS

Our study indicates that Internet-based home asthma telemonitoring can be successfully implemented in the group of patients without previous computer background.

ACKNOWLEDGEMENTS

This work was supported by New York State Center of Advance Technology grant "Computerized Pulmonary Monitoring Center", and NLM training grant LM07079.

References

1. National Heart, Lung and Blood Institute. Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma. NIH Publication No. 97-4051. 1997.
2. McFadden ER, Kiser R, De Groot WJ. Acute bronchial asthma. Relations between clinical and physiological manifestations. *N. Engl. J. Med.* 1973;288:221-225.
3. Hyland ME, Kenyon CAP, Allen R, Howarth P. Diary keeping in asthma: comparison of written and electronic methods. *BMJ.* 1993;306:487-489.
4. Clark NM, Evans D, Mellins RB. Patient use of peak flow monitoring. *Am. Rev. Respir. Dis.* 1992;145:722-725.
5. Finkelstein J, Hripcsak G. Monitoring of asthma severity in patients' homes using wireless technology. In: Proceedings of the AMIA Spring Congress, San Jose, CA; 1997; 123.
6. Finkelstein J, Hripcsak G, Cabrera M. Telematic system for monitoring of asthma severity in patients' homes. Accepted for MEDINFO'98, 9th World Congress on Medical Informatics. Seoul, Korea.
7. American Thoracic Society. Standardization of spirometry. 1994 Update. *Am. J. of Respir. and Crit. Care Med.* 1995;152:1107-1136.
8. Field MJ (ed). Telemedicine. A guide to assessing telecommunications in health care. National Academy Press. Washington, D.C., 1996.
9. Friedman CP, Wyatt JC. Evaluation Methods in Medical Informatics. Springer-Verlag New York, Inc. 1997.
10. Lessler JT. Choosing questions that people can understand and answer. *Medical Care.* 1995;33:AS203-AS208.